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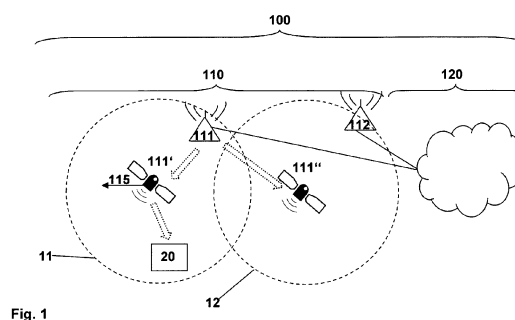
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(54) **METHOD FOR ENABLING COMMUNICATION BETWEEN A USER EQUIPMENT AND A MOBILE COMMUNICATION NETWORK BEING OR HAVING A NON-TERRESTRIAL NETWORK, USER EQUIPMENT, ANTENNA ENTITY OR FUNCTIONALITY, SYSTEM OR MOBILE COMMUNICATION NETWORK, PROGRAM AND COMPUTER-READABLE MEDIUM**

(57) The invention relates to a method for enabling communication between a user equipment and a mobile communication network, the mobile communication network being or at least comprising a part corresponding to or being a non-terrestrial network, wherein the user equipment is served by a base station entity being part of that non-terrestrial network or that non-terrestrial network part, wherein the base station entity has or is provided with - in view of serving or providing radio coverage to the user equipment - at least an antenna entity or functionality being either a satellite-based antenna entity or

functionality, or an antenna entity or functionality based on a high-altitude platform, the antenna entity or functionality moving relative to the earth surface along a direction of movement, thereby providing radio coverage to a radio cell, wherein the method comprises the step of -- operating the antenna entity or functionality, or -- configuring the antenna entity or functionality such that the shape of the coverage area of the radio cell is configured or configurable in a predefined manner other than circular or elliptical.



Description

BACKGROUND

[0001] The present invention relates a method for enabling communication between a user equipment and a mobile communication network being or having a non-terrestrial network, wherein the user equipment is served by a base station entity being part of that non-terrestrial network, wherein the base station entity has or is provided with - in view of serving or providing radio coverage to the user equipment - at least an antenna entity or functionality being either a satellite-based antenna entity or functionality, or an antenna entity or functionality based on a high-altitude platform.

[0002] Furthermore, the present invention relates to a user equipment communicating with a mobile communication network being or having a non-terrestrial network, wherein the user equipment is served by a base station entity being part of that non-terrestrial network, wherein the base station entity has or is provided with - in view of serving or providing radio coverage to the user equipment - at least an antenna entity or functionality being either a satellite-based antenna entity or functionality, or an antenna entity or functionality based on a high-altitude platform.

[0003] Additionally, the present invention relates to an antenna entity or functionality as part of a base station entity for enabling communication between a user equipment and a mobile communication network being or having a non-terrestrial network, wherein the user equipment is served by a base station entity being part of that non-terrestrial network, wherein the base station entity has or is provided with - in view of serving or providing radio coverage to the user equipment - at least an antenna entity or functionality being either a satellite-based antenna entity or functionality, or an antenna entity or functionality based on a high-altitude platform.

[0004] Furthermore, the present invention relates to a system or a mobile communication network for communication between a user equipment and the mobile communication network, the mobile communication network being or having a non-terrestrial network, wherein the user equipment is served by a base station entity being part of that non-terrestrial network, wherein the base station entity has or is provided with - in view of serving or providing radio coverage to the user equipment - at least an antenna entity or functionality being either a satellite-based antenna entity or functionality, or an antenna entity or functionality based on a high-altitude platform.

[0005] Furthermore, the present invention relates to a program and to a computer-readable medium for enabling communication between a user equipment and a mobile communication network according to the inventive method.

[0006] Mobile communication networks such as public land mobile networks are typically realized as cellular mobile communication networks, i.e. comprising (or using or being associated or assigned to a radio access network comprising) radio cells. Such cellular systems are known conforming to different mobile communication standards or radio access technologies, like 2G/3G/4G/5G radio access technologies (referring to the different generations of radio access technologies) and typically comprise (or consist of) cells (or radio cells) of one or a plurality of the respective radio access technology/radio access technologies. Such mobile communication networks that are purely or predominantly based on terrestrial infrastructures of the radio access network are typically organized throughout a country (or a part thereof, or a region within a country) in a repeating pattern of typically stationary (radio) cells (and associated base station entities) which typically belong to (or are used by or associated or assigned to) a mobile network operator (MNO).

Modern mobile communication networks, such as 5G systems, especially using 5G NR (new radio) radio (access) technology, are evolving using air-based and/or space-based infrastructure, hence relying, at least partly, on non-terrestrial infrastructure, especially in the form of satellites and/or high altitude platforms, HAPs, thereby realizing non-terrestrial networks, NTN (or satellite communication networks). Examples of such air-based and/or space based network infrastructure include, e.g., mobile satellite connectivity with low earth orbit (LEO) satellites, medium earth orbit (MEO) satellites and/or geostationary earth orbit (GEO) satellites and also so-called high altitude platforms or high altitude pseudo-satellites (HAPS).

Such non-terrestrial networks are able to provide global cellular connectivity to, e.g. handheld, devices or user equipments, typically using satellite or HAP coverage with quasi earth fixed beams, i.e. radio coverage is attempted to be provided, for a certain considered (quasi) fixed geographical area (of the considered radio cell), in an almost statical or unchanged manner during a certain time interval or until a certain point in time. This is in contrast to using earth-moving beams by means of which radio coverage is provided in a moving geographical area, or earth-moving radio cell, that is moving, relative to the earth surface, together with the movement of the satellite (or the high altitude platform device); such earth-moving radio cells typically being located around a geographical location, often corresponding to a projection of the current position of the satellite (or of the high altitude platform device), along a more or less vertical line, on to the earth surface.

However in practice, it is challenging to provide radio coverage for an extended geographical area and in an efficient manner, while simultaneously taking into consideration challenges such as an unevenly distributed population density and an associated demand for communication services being concentrated in some parts of the geographical area.

SUMMARY

[0007] An object of the present invention is to provide a technically simple, effective and cost-effective solution for enabling communication between a user equipment (and, typically, a multitude of user equipments located in a certain geographical area, and there having a certain distribution) and mobile communication network, wherein the mobile communication network is a non-terrestrial network (or at least comprises a non-terrestrial network; or wherein at least a part of the mobile communication network corresponds to or is a non-terrestrial network) and wherein the base station entity has or is provided with - in view of serving or providing radio coverage to the user equipment, or the plurality thereof - at least an antenna entity or functionality being either a satellite-based antenna entity or functionality, or an antenna entity or functionality based on a high-altitude platform. A further object of the present invention is to provide a corresponding user equipment, system or mobile communication network, and a corresponding program and computer-readable medium.

[0008] The object of the present invention is achieved by a method for enabling communication between a user equipment and a mobile communication network, the mobile communication network being or at least comprising a part corresponding to or being a non-terrestrial network, wherein the user equipment is served by a base station entity being part of that non-terrestrial network or that non-terrestrial network part, wherein the base station entity has or is provided with - in view of serving or providing radio coverage to the user equipment - at least an antenna entity or functionality being either a satellite-based antenna entity or functionality, or an antenna entity or functionality based on a high-altitude platform, the antenna entity or functionality moving relative to the earth surface along a direction of movement, thereby providing radio coverage to a radio cell, wherein the method comprises the step of

- operating the antenna entity or functionality, or
- configuring the antenna entity or functionality

such that the shape of the coverage area of the radio cell is configured or configurable in a predefined manner other than circular or elliptical.

[0009] It is thereby advantageously possible according to the present invention that it is possible to provide radio coverage in a more efficient manner: To provide radio coverage for an extended geographical area, typically a plurality of satellites or high altitude platform systems or devices (or non-terrestrial network components or elements) are required; hence, reducing the required number of such non-terrestrial network components is typically more (cost-)efficient. Furthermore, population, and consequently communication demand, is typically not evenly distributed on the considered geographical area; hence in order to reduce the relative performance requirements, and, hence, complexity, of non-terrestrial network components (e.g. satellites or high altitude platform devices), by means of being able to shape the coverage area of associated radio cells, it is advantageously possible to focus communication performances of more than one non-terrestrial network component or device, e.g. on a densely populated area.

[0010] The present invention is focused on low earth orbit (LEO) satellites or high altitude platform entities which typically are located up to 300 km until 1500 km above ground (especially 800 km to 1000 km), and are, typically, traveling at a velocity of around 7 km/s, resulting in a round trip time about the globe of typically about 100 minutes.

[0011] According to the present invention, the user equipment is connected to (or is in) the mobile communication network that is a non-terrestrial network; alternatively, the mobile communication network at least comprises a part that corresponds to or is a non-terrestrial network. The user equipment is (or, rather, the plurality of user equipments are) served by the base station entity as in a conventionally known mobile communication network; however, the serving base station entity is assumed as being part of the non-terrestrial network (or, at least, the non-terrestrial network part) of the mobile communication network.

According to the present invention, the base station entity is provided with at least one antenna entity or functionality (but preferably, the base station entity is provided with more than one antenna entities or functionalities), the at least one antenna entity or functionality (of the base station entity) is either a satellite-based antenna entity or functionality (i.e. located onboard a satellite), or an antenna entity or functionality based on a high-altitude platform device (i.e. located onboard such a high altitude platform device). The base station entity is able to serve (i.e. providing communication services to) the user equipment (or plurality thereof) by means of or using the at least one antenna entity or functionality - typically using a service (radio) link towards and/or from the user equipment in order to realize downlink and/or uplink data transmissions.

According to the present invention, the whole (or mayor parts of the) functionality of the base station entity might be located onboard the satellite or onboard the high-altitude platform device (hence, in this case, typically requiring some kind of backhaul connectivity to an earth or ground station and/or to another satellite or high altitude platform device). Alternatively, the mayor parts of the functionality of the base station entity might be located either at or in an earth or ground station, or at or in another satellite or high altitude platform device (in this case, typically requiring some kind of

feeder link or feeder connectivity to an earth or ground station and/or to another satellite or high altitude platform device). The antenna entity or functionality (either as part of the satellite or as part of the high altitude platform device) typically moves relative to the earth surface along a direction of movement (and/or following a certain, typically predefined, trajectory), and is thereby able to provide radio coverage to a radio cell, i.e. a geographical area where user equipments are able to be served by that satellite or high altitude platform device. In case of a satellite-based antenna entity or functionality, the trajectory of the movement of the satellite (at least from a fixed or quasi stationary ground perspective) can typically very well be approximated by an almost straight line as the curvatures of such satellite trajectories is almost negligible from such a perspective. However, in case of a high-altitude platform device, the trajectory of such a device might be less straight, i.e. having a non-negligible curvature.

[0012] According to the present invention the antenna entity or functionality is operated or is configured such that the shape of the coverage area of the radio cell is configured or configurable in a predefined manner (or in a configurable manner) other than circular or elliptical, as a circularly or elliptically shaped coverage area of the radio cell typically corresponds to the normal or to-be-expected shape of a coverage area using standard antenna equipment, especially with none-steerable antennas. Typically, the coverage area on the ground of a conventionally known low earth orbit satellite is typically a circle or an ellipse moving over the ground. Likewise, the coverage area of conventionally known high altitude platform devices or systems typically also corresponds to a circle or an ellipse, either moving over the ground or being (rather) stationary, e.g. in case of drones flying between 5 and 25 km above ground. Especially according to the present invention, a specifically defined shape or form of the radio cell or of its coverage area is realized by means of conforming, as much as possible, the shape of a coverage area obtained by a specifically considered configuration or mode of operation of the antenna entity or functionality to the desired geometrical form or shape; one possibility to measure whether the shape of the coverage area conforms to (or matches) the desired shape could, e.g., be to attempt to reduce, especially as much as technically meaningfully possible, either one or both of

- the (absolute or relative) surface area of the radio cell not covering the desired geometrical form or shape,
- the (absolute or relative) surface area of the radio cell extending the desired geometrical form or shape; another possibility of such a measure could be to mandate a maximum (absolute or relative) distance between the radio cell and the desired geometrical form or shape, e.g. along a direction orthogonal to an edge of the desired geometrical form or shape, or along a direction from the center (or weighted center; 'center of gravity') of the coverage area or of the desired geometrical form or shape. In this respect, the effective extension of the radio cell considered could, e.g., be defined by considering those locations where a signal strength (of radio signals received, by the user equipment, from the antenna entity or functionality) exceeds a certain predefined (absolute or relative) threshold value.

[0013] For the sake of simplicity, in the context of the present invention, it is assumed that one radio cell or coverage area is provided by one satellite or high altitude platform device.

[0014] According to the present invention, the base station entity is provided with at least one antenna entity or functionality (but preferably, the base station entity is provided with more than one antenna entities or functionalities), the at least one antenna entity or functionality (of the base station entity) is either a satellite-based antenna entity or functionality (i.e. located onboard a satellite), or an antenna entity or functionality based on a high-altitude platform device (i.e. located onboard such a high altitude platform device). The base station entity is able to serve (i.e. providing communication services to) the considered user equipment by means of or using the at least one antenna entity or functionality - typically using a service (radio) link towards and/or from the user equipment in order to realize downlink and/or uplink data transmissions.

According to the present invention, the whole (or mayor parts of the) functionality of the base station entity might be located onboard the satellite or onboard the high altitude platform device (hence, in this case, typically requiring some kind of backhaul connectivity to an earth or ground station and/or to another satellite or high altitude platform device). Alternatively, the mayor parts of the functionality of the base station entity might be located either at or in an earth or ground station, or at or in another satellite or high-altitude platform device (in this case, typically requiring some kind of feeder link or feeder connectivity to an earth or ground station and/or to another satellite or high altitude platform device).

[0015] According to the present invention, it is advantageously possible and preferred that the antenna entity or functionality is operated or configured such that, in a first mode of operation, the shape of the coverage area of the radio cell is configured or configurable in a first predefined manner other than circular or elliptical, and, in a second mode of operation, the shape of the coverage area of the radio cell is configured or configurable in a second predefined manner, wherein especially the first mode of operation is applied at a first point in time or during a first time interval, and the second mode of operation is applied at a second point in time or during a second time interval.

[0016] It is thereby advantageously possible that the coverage area is able to be modified and/or adapted to different requirements (e.g. related to the demand of communication services), especially different requirements at different points in time (especially in case, but not necessarily, that the radio cell corresponds to an earth-moving radio cell).

[0017] According to the present invention, it is advantageously furthermore possible and preferred that the shape of the coverage area of the radio cell corresponds, at least in or during one mode of operation, to one of the following:

- a simple polygon, especially a convex polygon or a quadrilateral, especially a rectangle, a parallelogram, or a rhombus
- regular polygon, especially an equilateral triangle, or a square, or an equilateral and equiangular pentagon, hexagon, or octagon,
- a general polygon, especially being defined by a number of points or geographical locations such that a certain area, especially a populated area such as a city, is covered.

[0018] It is thereby advantageously possible according to the present invention that the coverage area of the radio cell is able to be configured very flexibly.

Especially, the coverage area of the radio cell corresponds to a simple polygon, i.e. a polygon having neither intersecting sides nor holes, and (cumulatively or alternatively) especially a convex polygon, i.e. every line that does not contain any edge of the polygon intersects the polygon in at most two points. Typical examples of such, especially simple and convex, polygons comprise a triangle, or a quadrilateral, especially a rectangle, or a parallelogram, or a rhombus.

Furthermore especially, the coverage area of the radio cell corresponds to a regular polygon, especially an equilateral triangle, or a square, or an equilateral and equiangular pentagon, hexagon, or octagon. Furthermore especially, the coverage area of the radio cell corresponds to a general polygon (typically still a simple polygon but not necessarily a convex polygon), especially being defined by a number of points or geographical locations such that a certain area, especially a populated area such as a city, is covered.

[0019] According to the present invention, it is furthermore advantageously possible and preferred that the antenna entity or functionality moving relative to the earth surface along a direction of movement provides radio coverage to a moving area corresponding to an earth-moving radio cell.

[0020] According to such a preferred embodiment of the present invention, the radio cell or coverage area is an earth-moving radio cell or coverage area, typically moving or travelling on the earth surface in unison with the movement of the satellite or high-altitude platform device. This means that a considered satellite or high-altitude platform device is able to provide coverage and/or service (or communication services) only during a defined period of time or time interval to a user equipment that is assumed being stationary or almost stationary (relative to the ground speed of the satellite or high-altitude platform) on or above the earth surface.

In case of such an earth-moving radio cell, this defined period of time or time interval (of coverage or service), of course, depends on the size and/or the geometry of the earth-moving radio cell or coverage area (and also on its orientation), and on the velocity and/or direction of movement and/or trajectory of the satellite or high-altitude platform device above ground.

The antenna entity or functionality (either as part of the satellite or as part of the high-altitude platform device) thus moves relative to the earth surface along a direction of movement (and/or following a certain, typically predefined, trajectory), and is thereby able to provide radio coverage to the earth-moving radio cell. In case of a satellite-based antenna entity or functionality, the trajectory of the movement of the satellite (at least from a fixed or quasi stationary ground perspective) can typically very well be approximated by an almost straight line as the curvatures of such satellite trajectories is almost negligible from such a perspective. However, in case of a high-altitude platform device, the trajectory of such a device might be less straight, i.e. having a non-negligible curvature.

[0021] According to the present invention, it is furthermore advantageously possible and preferred that the antenna entity or functionality moving relative to the earth surface along a direction of movement provides radio coverage to a static area corresponding to an earth-fixed radio cell.

[0022] According to such a preferred embodiment of the present invention, the radio cell or coverage area is an earth-fixed radio cell or coverage area, typically staying above a geographical area (and therefore being able to provide radio coverage) for a certain time interval of several tens of seconds or several minutes before moving or travelling (especially in case of a satellite) beyond or past that geographical area. Especially in case of flying high altitude platform devices, such systems might be able to stay essentially earth-fixed, and, hence, would have the possibility to provide radio coverage either without an explicitly defined service time interval, or, at least, for a much longer service time interval.

[0023] According to the present invention, it is furthermore advantageously possible and preferred that the shape of the coverage area of the radio cell is configured or configurable in a predefined manner, especially such that a rather rectangular radio cell is generated, wherein especially two of the sides of the radio cell or coverage area are essentially parallel to the direction of movement of the antenna entity or functionality or essentially parallel to the central trajectory path of the radio cell,

wherein especially one or more of the following is realized:

- the antenna entity or functionality steers, especially using multiple input multiple output beam steering or beam

forming, the transmission in a manner such that the resulting coverage area approximately is or corresponds to the predefined shape of the coverage area of the radio cell, especially a rectangle or a rectangle having rounded corners,
 -- the antenna entity or functionality generates at least one moving beam, or spot beam, wherein the moving beam is oriented in different spatial directions at different points in time such that the coverage area is swept through during a predetermined time interval and such that the resulting coverage area approximately is or corresponds to the predefined shape of the coverage area of the radio cell, especially a rectangle or a rectangle having rounded corners,

-- the antenna entity or functionality comprises a multitude of antenna panels, wherein the multitude of antenna panels create constructive and/or destructive interference such that the resulting coverage area approximately is or corresponds to the predefined shape of the coverage area of the radio cell, especially a rectangle or a rectangle having rounded corners,

-- the antenna entity or functionality generates a multitude of differently shaped static or quasi-static spot beams such that the resulting coverage area approximately is or corresponds to the predefined shape of the coverage area of the radio cell, especially a rectangle or a rectangle having rounded corners.

[0024] It is thereby advantageously possible according to the present invention that the coverage area of the radio cell is able to be configured in a very flexibly manner as to its shape or form and that this is able to be realized using a plurality of different technical solutions or combinations of solutions.

[0025] According to the present invention, it is furthermore advantageously possible and preferred that a reference location information as well as a service time information is transmitted, by the base station entity or by the antenna entity or functionality, to the user equipment,

wherein the service time information relates to until when the base station entity, or the antenna entity or functionality likely stops serving the currently covered area,

wherein the reference location information corresponds, at least approximately, to the shape of the coverage area of the radio cell produced or generated by the antenna entity or functionality,

wherein especially the base station entity transmits, and the user equipment receives, the reference location information and the service time information as information elements as part of a system information block, especially broadcast by the base station entity, especially system information block 19 with 3GPP NR technology,

wherein especially the reference location information comprises, in case of a rectangularly shaped coverage area of the radio cell, at least one reference point information, at least one height information and/or at least one width information, preferably a first height information, a second height information, a first width information and a second width information, wherein the height information preferably corresponds to the extension of the coverage area, from the reference point, in a direction essentially parallel to the direction of movement of the antenna entity or functionality, and wherein the width information preferably corresponds to the extension of the coverage area, from the reference point, in a direction essentially orthogonal to the direction of movement of the antenna entity or functionality,

wherein especially the reference location information comprises, in case of a coverage area of the radio cell shaped as a simple polygon or a regular polygon or a general polygon, a plurality of pieces of reference point information, especially corresponding to the corner points of the polygonal coverage area.

[0026] It is thereby advantageously possible according to the present invention that the reference location information as well as the service time information is able to be transmitted, by the base station entity or by the antenna entity or functionality, to the user equipment in an efficient manner. Especially according to the present invention, the reference location information is indicated in remaining UTC seconds in 10 ms units since 00:00:00 on Gregorian calendar date 1 January, 1900 (midnight between Sunday, December 31, 1899 and Monday, January 1, 1900).

Furthermore according to the preferred embodiment where a reference location information as well as a service time information is transmitted to the user equipment: As already mentioned, the antenna entity or functionality (either as part of the satellite or as part of the high altitude platform device) typically moves relative to the earth surface along a direction of movement; in case of a satellite-based antenna entity or functionality, the trajectory of the movement of the satellite can typically very well be approximated by an almost straight line; however, in case of a high-altitude platform device, the trajectory of such a device might be less straight, i.e. having a non-negligible curvature.

Especially, the service time information corresponds to a general service time information, i.e. applicable to all or almost all user equipments located within the coverage area of the radio cell. The reference location information relates to a specific part of the coverage area (or, in case of an earth-moving radio cell, to a specific part of the currently covered area), typically the center of the coverage area. The (general) service time information relates to until when (i.e. at which (future) point in time) the base station entity (via its satellite-based antenna entity or functionality) likely stops being able to serve the coverage area.

It is assumed according to the present invention that the reference location information and the service time information is transmitted repeatedly, especially in regular time intervals of, e.g., 320 ms or 640 ms or 1280 ms or of another duration, and that the transmitted values of the reference location information and the service time information are (if applicable) updated in order to correspond to the correct (or, if applicable, current) values either at the transmission point in time, or at a point in time corresponding to a predetermined (comparatively small) offset time relative to the transmission point in time; hence, the successive indications (by the base station entity, and towards the user equipment) of the (repeatedly updated) reference location information provide (or correspond to) a sequence of points or locations (typically on the earth surface) that, collectively, at least roughly define a travel path in case of an earth-moving radio cell (or, at least, from which such a travel path could be derived), especially a central trajectory path of the radio cell.

[0027] Furthermore, the present invention relates to a user equipment communicating with a mobile communication network, the mobile communication network being or at least comprising a part corresponding to or being a non-terrestrial network, wherein the user equipment is served by a base station entity being part of that non-terrestrial network or that non-terrestrial network part, wherein the base station entity has or is provided with - in view of serving or providing radio coverage to the user equipment - at least an antenna entity or functionality being either a satellite-based antenna entity or functionality, or an antenna entity or functionality based on a high-altitude platform, the antenna entity or functionality moving relative to the earth surface along a direction of movement, thereby providing radio coverage to a radio cell, wherein the user equipment is configured such that the antenna entity or functionality is operated or configured such that the shape of the coverage area of the radio cell is configured or configurable in a predefined manner other than circular or elliptical.

[0028] Furthermore, the present invention relates to an antenna entity or functionality as part of a base station entity for enabling communication between a user equipment and a mobile communication network, the mobile communication network being or at least comprising a part corresponding to or being a non-terrestrial network, wherein the user equipment is served by the base station entity being part of that non-terrestrial network or that non-terrestrial network part, wherein the base station entity has or is provided with - in view of serving or providing radio coverage to the user equipment - at least the antenna entity or functionality being either a satellite-based antenna entity or functionality, or an antenna entity or functionality based on a high-altitude platform, the antenna entity or functionality moving relative to the earth surface along a direction of movement, thereby providing radio coverage to a radio cell, wherein the antenna entity or functionality is configured such that it is operated or able to be operated such that the shape of the coverage area of the radio cell is configured or configurable in a predefined manner other than circular or elliptical.

[0029] Furthermore, the present invention relates to a system or mobile communication network for communication between a user equipment and the mobile communication network, the mobile communication network being or at least comprising a part corresponding to or being a non-terrestrial network, wherein the user equipment is served by a base station entity being part of that non-terrestrial network or that non-terrestrial network part, wherein the base station entity has or is provided with - in view of serving or providing radio coverage to the user equipment - at least an antenna entity or functionality being either a satellite-based antenna entity or functionality, or an antenna entity or functionality based on a high-altitude platform, the antenna entity or functionality moving relative to the earth surface along a direction of movement, thereby providing radio coverage to a radio cell, wherein the system of mobile communication network is configured such that the antenna entity or functionality is operated or configured such that the shape of the coverage area of the radio cell is configured or configurable in a predefined manner other than circular or elliptical.

[0030] Additionally, the present invention relates to a program comprising a computer readable program code which, when executed on a computer and/or on a user equipment and/or on a base station entity of a mobile communication network and/or on an antenna entity or functionality of a base station entity, or in part on a user equipment and/or in part on a base station entity of a mobile communication network and/or in part on an antenna entity or functionality of a base station entity, causes the computer and/or the user equipment and/or the base station entity and/or the antenna entity or functionality to perform the inventive method.

[0031] Still additionally, the present invention relates to a computer-readable medium comprising instructions which when executed on a computer and/or on a user equipment and/or on a base station entity of a mobile communication network and/or on an antenna entity or functionality of a base station entity, or in part on a user equipment and/or in part on a base station entity of a mobile communication network and/or in part on an antenna entity or functionality of a base station entity, causes the computer and/or the user equipment and/or the base station entity and/or the antenna entity or functionality to perform the inventive method.

[0032] These and other characteristics, features and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention. The description is given for the sake of example only, without limiting the scope of the invention. The reference figures quoted below refer to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033]

5 Figure 1 schematically illustrates the situation of a user equipment in a mobile communication network being a non-terrestrial network or at least comprising a part corresponding to a non-terrestrial network, the user equipment being served by a base station entity having at least an antenna entity or functionality being a satellite-based antenna entity or functionality.

10 Figure 2 schematically illustrates the situation of the user equipment being served by a base station entity having a satellite-based antenna entity or functionality moving relative to the earth surface along a direction of movement, thereby providing radio coverage to a moving area corresponding to an earth-moving radio cell.

15 Figures 3 and 4 schematically illustrate the user equipment being served by a base station entity with an antenna entity or functionality providing a rectangular radio coverage area.

Figures 5 and 6 schematically illustrate different exemplary embodiment to realize a rectangular radio coverage area.

DETAILED DESCRIPTION

20 **[0034]** The present invention will be described with respect to particular embodiments and with reference to certain drawings, but the invention is not limited thereto but only by the claims. The drawings described are only schematic and are nonlimiting. In the drawings, the size of some of the elements may be exaggerated and not drawn on scale for illustrative purposes.

25 **[0035]** Where an indefinite or definite article is used when referring to a singular noun, e.g. "a", "an", "the", this includes a plural of that noun unless something else is specifically stated.

[0036] Furthermore, the terms first, second, third and the like in the description and in the claims are used for distinguishing between similar elements and not necessarily for describing a sequential or chronological order. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other sequences than described or illustrated herein.

30 **[0037]** In Figure 1, a user equipment 20 is schematically shown in a mobile communication network 100. In the example, the mobile communication network 100 comprises an access network 110 and a core network 120. The mobile communication network 100 is preferably a cellular telecommunications network comprising typically a plurality of network cells (or radio cells). According to the present invention, the mobile communication network 100 comprises or uses or is associated or assigned to a radio access network 110, and the radio access network 110 (of the mobile communication network 100) comprises at least one base station entity, but typically a plurality of base station entities. Figure 1 schematically and exemplarily shows a first base station entity 111 and a second base station entity 112.

[0038] The mobile communication network 100 (or telecommunications network 100) is or at least comprises a part corresponding to or being a non-terrestrial network. The user equipment 20 is served by the (first) base station entity 111 being part of that non-terrestrial network or that non-terrestrial network part.

The base station entity 111 has or is provided with - in view of serving or providing radio coverage to the user equipment 20 - at least one antenna entity or functionality 111' being either a satellite-based antenna entity or functionality, or an antenna entity or functionality based on a high-altitude platform; Figure 1 primarily shows the alternative of a satellite-based antenna entity or functionality 111'. The antenna entity or functionality 111' - being part of the non-terrestrial network (part) of the mobile communication network 100 - is moving relative to the earth surface along a direction of movement which is schematically indicated by reference sign 115 in Figure 1. The base station entity 111, via or by means of the antenna entity or functionality 111', is thereby able to provide radio coverage to an area (on the earth's surface), corresponding to a radio cell 11. The second or further base station entity 112 is also schematically shown in Figure 1 as well as a further antenna entity or functionality 111" providing or serving a further radio cell 12. According to alternative embodiments of the present invention, the antenna entity or functionality 111' (moving relative to the earth surface along a direction of movement 115) provides radio coverage to a moving area, i.e. radio cell 11 corresponds to an earth-moving radio cell 11; alternatively, the antenna entity or functionality 111' (still moving, typically, relative to the earth surface along the direction of movement 115) provides radio coverage to a static area, i.e. radio cell 11 corresponds to an earth-fixed radio cell 11.

55 **[0039]** According to the present invention, the base station entity 111 is provided with at least one antenna entity or functionality 111' (but preferably, the base station entity 111 is provided with more than one antenna entities or functionalities 111', 111"), the at least one antenna entity or functionality 111' (of the base station entity 111) is either a satellite-based antenna entity or functionality (i.e. located onboard a satellite as shown in Figure 1), or an antenna entity

or functionality based on a high-altitude platform device (i.e. located onboard such a high altitude platform device, not explicitly shown in Figure 1). The base station entity 111 is able to serve (i.e. providing communication services to) the considered user equipment 20 by means of or using the at least one antenna entity or functionality 111' (or, by means of using the first antenna entity or functionality 111' during one time interval, and by means of using the second antenna entity or functionality 111" during a subsequent further time interval), especially in case of an earth-moving radio cell 11; in case of an earth-fixed radio cell 11, such a handover operation (of the base station entity 111 serving the considered user equipment 20 by means of using the first antenna entity or functionality 111' during a first time interval, and by means of using the second antenna entity or functionality 111" during a subsequent second time interval) is typically also required in case that the antenna entities or functionalities 111', 111" are satellite-based but not necessarily in case that the antenna entities or functionalities 111', 111" are based on a high-altitude platform device. In any case, typically, a service (radio) link towards and/or from the considered user equipment 20 is used in order to realize downlink and/or uplink data transmissions; this is schematically indicated, in Figure 1, by means of a dotted arrow, directed from the antenna entity or functionality 111' towards the considered specific user equipment 20.

[0040] Figure 1 schematically and exemplarily shows a configuration where the mayor parts of the functionality of the base station entity 111 is located separated from the antenna entity or functionality 111', especially at or in an earth or ground station 111; alternatively, the mayor parts of the functionality of the base station entity 111 could also be located at or in another satellite or high-altitude platform device. In such a scenario where the mayor parts of the functionality of the base station entity 111 are located separated from the antenna entity or functionality 111' (and from the further antenna entity or functionality 111"), the antenna entity or functionality 111' (and the further antenna entity or functionality 111"), typically requires some kind of feeder link or feeder connectivity (i.e. to the earth or ground station and/or to another satellite or high altitude platform device) ; this is schematically indicated, in Figure 1, by means of dotted arrows, directed from the base station entity 111 towards the antenna entities or functionalities 111', 111", respectively.

Alternatively to the configuration shown in Figure 1, it is also possible and preferred according to the present invention that the whole (or mayor parts of the) functionality of the base station entity 111 might be located onboard the satellite or onboard the high altitude platform device. In this case, a backhaul connectivity is typically provided, from the combined satellite-based base station entity 111 comprising the antenna entity or functionality 111', to an earth or ground station and/or to another satellite or high-altitude platform device.

[0041] In Figure 2, the situation of the user equipment 20 being served by the base station entity 111 having the satellite-based antenna entity or functionality 111' moving relative to the earth surface along a direction of movement 115 is schematically shown for two different locations of the specific user equipment 20. At a considered point in time, the base station entity 111, via the antenna entity or functionality 111', provides radio coverage to the radio cell 11 as schematically shown in Figure 2, wherein this moving radio cell typically moves together with the antenna entity or functionality 111', i.e. corresponds to an earth-moving radio cell 11. In the direction of movement 115 of the antenna entity or functionality 111', the earth-moving radio cell 11 comprises a central part 116 typically comprising the location of the reference location information 116, e.g., in the center of the radio cell 11. The exemplarily shown specific user equipment 20 in its first location, being located at or on the central part of the radio cell 11, would be able to be served by the base station entity 111 and via the antenna entity or functionality 111' during the whole time interval required for the antenna entity or functionality 111' to sweep over the radio cell 11 - i.e. from the point in time the radio coverage, by means of the antenna entity or functionality 111', is first provided to a region (on the central part of the radio cell 11) indicated by means of reference sign 117 until the point in time the radio coverage, by means of the antenna entity or functionality 111', is lost from the point of view of a region (on the central part of the radio cell 11) indicated by means of reference sign 118. In contrast thereto (i.e. to the specific user equipment 20 being located in its first considered location at or on the central part of the radio cell 11), in case the specific user equipment 20 is located rather distanced from the central part of the radio cell 11 (to the left hand side in Figure 2) the time interval it experiences or sees radio coverage (provided by that same antenna entity or functionality 111') is much shorter.

Roughly, the durations of the corresponding service time intervals of these two exemplarily considered locations of the user equipment 20 are able to be schematically represented by the lengths of the two rectangles (parallel to the direction of movement 115) shown in Figure 2.

The radio cell 11 schematically and exemplarily shown in Figure 2 corresponds to a circularly (or elliptically) shaped radio cell 11. Due to the distance (indicated by means of reference sign 25 in Figure 2) of the second location of the user equipment 20 with respect to the central part of the radio cell 11 (corresponding to the first location of the user equipment 20), and due to the roughly circular (or elliptical) shape of the radio cell 11, the service time interval is much shorter in case the specific user equipment 20 is located at the second location.

According to the present invention, wherein the antenna entity or functionality 111' is operated or configured such that the shape of the coverage area of the radio cell 11 is configured or configurable in a predefined manner other than circular or elliptical - an example of which is schematically shown in Figures 3 and 4.

[0042] In Figures 3 and 4 the user equipment 20 is served by the base station entity, and the base station entity has or is associated with the antenna entity or functionality 111'. Again, the radio cell 11 has or comprises (both in the

exemplary embodiment of Figure 3 as well as in the embodiment of Figure 4), in the direction of movement 115 of the antenna entity or functionality 111', a central part 116 typically comprising the location of the reference location information 116, e.g., in a central part or in the center of the radio cell 11. In the exemplarily shown embodiment of Figures 3 and 4, the antenna entity or functionality 111' provides a rectangular radio coverage area 11 or radio cell 11, especially having - at least roughly - an extension of (e.g. a certain number of kilometers) h parallel or substantially parallel to its direction of movement 115, and an extension of (e.g. a certain number of kilometers) w orthogonal or substantially orthogonal to its direction of movement 115.

The representation of Figure 3 is able to be understood as rather showing an earth-fixed radio cell 11. Considering the movement 115 of the antenna entity or functionality 111', the base station entity 111 (or antenna entity or functionality 111') is able to serve (or to provide communication services to user equipments 20 located in) the coverage area 11 for a certain period of time, but the radio cell 11 or coverage area 11 is essentially rather fixed, i.e. does either not move at all, or, at least, does not move considerably, especially not (except for marginal effects) at its boundaries parallel to the direction of movement 115; regarding its boundaries orthogonal to the direction of movement 115, there might be a drift of the extension (h) of the coverage area of the radio cell 11, depending on from which direction (especially from which altitude or elevation from the perspective of the coverage area of the radio cell 11) the antenna entity or functionality 111' provides its radio coverage.

The representation of Figure 4 is able to be understood as rather showing an earth-moving radio cell 11. Considering the movement 115 of the antenna entity or functionality 111', the base station entity 111 (or antenna entity or functionality 111') serves (or provides communication services to user equipments 20 located in) the coverage area 11 at a first point in time, and the radio coverage moves to coverage area 11' at a later (or second) point in time.

The exemplarily shown user equipment 20 is able to be served, by the base station entity 111 and via the antenna entity or functionality 111', during a certain period of time, in case of the earth-moving radio cell 11, 11' shown in Figure 4, the time interval required for the antenna entity or functionality 111' to sweep over (the height extension of the radio coverage area of) the radio cell 11 - i.e. from the point in time the radio coverage, by means of the antenna entity or functionality 111', is first provided to a region indicated by means of reference sign 117 until the point in time the radio coverage, by means of the antenna entity or functionality 111', is lost from the point of view of a region indicated by means of reference sign 118. By means of providing a rather rectangular extension of the radio coverage area 11, the service time interval is rather independent from the user equipment's lateral distance from the central part of the radio cell 11

[0043] In any case and irrespective of the radio cell 11 being or corresponding to a rather earth-moving radio cell (cf. Figure 4) or to a rather earth-fixed radio cell (cf. Figure 3), it is preferred according to the present invention that the base station entity 111 (via the antenna entity or functionality 111') transmits, and the user equipment 20 receives, the reference location information 116 and the service time information (being in both generally applicable to user equipments 20 located within the respective coverage area 11, i.e. irrespective of their lateral distance from the central part of the coverage area. Especially, the reference location information 116 relates to a specific part of the radio cell 11, and the service time information, or also called general service time information, relates to until when the base station entity 111 likely stops serving the radio cell 11 (especially due to the movement of the satellite-based antenna entity or functionality 111' being moving).

[0044] By means of the present invention, it is advantageously possible to provide shape-optimized coverage areas, and this for earth-moving radio cells 11 and as well for earth-fixed radio cells 11. With such an optimization, realized especially by means of using advanced antenna technologies at the antenna entity or functionality (especially onboard of satellites, especially low earth orbit satellites, or high-altitude platform devices), it is advantageously possible to overcome drawbacks arising from the "classical approach" (with circular or elliptic coverage). Hence a customized creation of cellular coverage is able to be applied using satellite-based antenna entities or functionalities or high-altitude platform-based antenna entities or functionalities (or also unmanned aerial vehicle-based antenna entities or functionalities), e.g. flying above the ground.

[0045] Especially, it is preferred according to the present invention that the shape of the coverage area of the radio cell 11 corresponds, at least in or during one mode of operation, to one of the following:

- a simple polygon, especially a convex polygon or a quadrilateral, especially a rectangle, a parallelogram, or a rhombus
- regular polygon, especially an equilateral triangle, or a square, or an equilateral and equiangular pentagon, hexagon, or octagon,
- a general polygon, especially being defined by a number of points or geographical locations such that a certain area, especially a populated area such as a city, is covered.

[0046] Especially, shape-optimized coverage areas (especially a rather rectangular radio cell 11) are able to be realized by means of using at least one out of the following:

-- multiple input multiple output (MIMO) beam steering or beam forming (i.e. the antenna entity or functionality 111' steers, especially using multiple input multiple output beam steering or beam forming, the transmission in a manner such that the resulting coverage area approximately is or corresponds to the predefined shape of the coverage area of the radio cell 11),

-- beam sweeping (i.e. the antenna entity or functionality 111' generates at least one moving beam, or spot beam, wherein the moving beam is oriented in different spatial directions at different points in time such that the coverage area is swept through during a predetermined time interval and such that the resulting coverage area approximately is or corresponds to the predefined shape of the coverage area of the radio cell 11),

-- multiple antenna panels (i.e. the antenna entity or functionality 111' comprises a multitude of antenna panels, wherein the multitude of antenna panels create constructive and/or destructive interference such that the resulting coverage area approximately is or corresponds to the predefined shape of the coverage area of the radio cell 11),

-- spot beams (i.e. the antenna entity or functionality 111' generates a multitude of differently shaped static or quasi-static spot beams such that the resulting coverage area approximately is or corresponds to the predefined shape of the coverage area of the radio cell 11).

[0047] For example, the possibility to realize shape-optimized coverage areas is able to be realized, according to the present invention as schematically shown in Figure 5, by means of using, as part of the antenna entity or functionality 111', a plurality of antenna panels 1110 or antenna elements 1110, wherein each one of such antenna panels 1110 covers a specific sub area or portion 1111 of the radio coverage area 11 of the radio cell.

[0048] Furthermore exemplarily, the possibility to realize shape-optimized coverage areas is also able to be realized, according to the present invention as schematically shown in Figure 6, by means of using at least one antenna beam that is swiped through the coverage area 11: E.g. the area of the radio cell 11 is able to be covered by means of comparatively quickly scanning or sweeping through a plurality of different locations such as to, e.g., provide coverage to a first location 1112 at a first point in time, to a second location 1113 at a second point in time, to a third location 1114 at a third point in time, to a fourth location 1115 at a fourth point in time, and so forth in order to cover and thereby providing radio coverage to the radio cell 11. Of course, it is advantageously possible to use more than one antenna beam, or even one antenna beam per coverage line (e.g. between the first and second locations 1112, 1113, or between the third and fourth locations 1114, 1115). Especially this scanning or sweeping of an antenna beam might be realized by means of a continuous movement or by means of discontinuously targeting different discrete positions (at specific respective points in time).

[0049] It is especially preferred according to the present invention that the antenna entity or functionality 111' is operated or configured such that, in a first mode of operation, the shape of the coverage area of the radio cell 11 is configured or configurable in a first predefined manner other than circular or elliptical, and, in a second mode of operation, the shape of the coverage area of the radio cell 11 is configured or configurable in a second predefined manner,

wherein especially the first mode of operation is applied at a first point in time or during a first time interval, and the second mode of operation is applied at a second point in time or during a second time interval.

In this respect, it is especially preferred according to the present invention that a dynamic coverage area is able to be created, supporting the flexible provision of satellite network capacity depending on the current need, i.e. in crowded regions coverage provided by satellites might be configured more in a more focused manner while in rural areas or over the oceans another configuration applies, having a wider coverage area.

[0050] Additionally, it is preferred according to the present invention that the reference location information 116 as well as the (general) service time information is transmitted, by the base station entity 111 (or by the antenna entity or functionality 111') to the user equipment 20. The service time information relates to until when the base station entity 111 (or the antenna entity or functionality 111') likely stops serving the currently covered area, and the reference location information corresponds, at least approximately, to the shape of the coverage area of the radio cell 11 produced or generated by the antenna entity or functionality 111'.

Especially the base station entity 111 transmits, and the user equipment 20 receives, the reference location information and the service time information as information elements as part of a system information block, especially broadcast by the base station entity, especially system information block 19 with 3GPP NR technology 111.

In case of a rectangularly shaped coverage area of the radio cell 11, the reference location information especially comprises at least one reference point information, at least one height information (h) and/or at least one width information (w), preferably a first height information, a second height information, a first width information and a second width information, wherein the height information preferably corresponds to the extension of the coverage area, from the reference point, in a direction essentially parallel to the direction of movement 115 of the antenna entity or functionality 111', and wherein the width information preferably corresponds to the extension of the coverage area, from the reference point, in a direction essentially orthogonal to the direction of movement 115 of the antenna entity or functionality 111'.

In case of a coverage area of the radio cell (11) being shaped as a simple polygon or a regular polygon or a general polygon, the reference location information especially comprises a plurality of pieces of reference point information,

especially corresponding to the corner points of the polygonal coverage area. Hence, for the signaling of the satellite-created (or high-altitude platform-created) rectangular or other shaped coverage area, related radio resource control, RRC, signaling the respective radio technology is preferably utilized, in case of 3GPP new radio, NR, especially the system information broadcast, e.g. system information block, SIB 19, by means of which the related information is added using RRC signaling. E.g. for a rectangular shape of the coverage area 11, the coverage area height and width is transmitted using RRC signalling:

- regarding the height of the coverage area 11: $h1 : RP : h2$ (so distance $\frac{1}{2} H$ ($h1$) in direction of moving satellite coverage + $\frac{1}{2} H$ ($h2$) in opposite direction);
- regarding the width of the coverage area 11: $w1 : RP : w2$ (so distance $\frac{1}{2} W$ ($w1$) left in direction of moving satellite coverage + $\frac{1}{2} W$ ($w2$) right of central line);

with such signalling ($h1=h2$ & $w1=w2$), the reference point 116 is located in the center (center of gravity) of the coverage area rectangle; alternatively with ($h1 \neq h2$ & $w1 \neq w2$) the reference point 116 is located flexibly inside the rectangle; with ($h1=h2=w1=w2$) the reference point 116 corresponds to the center of a quadratic coverage area 11, and with ($h1+h2=w1+w2$), the reference point is located flexibly inside of a quadratic coverage; optionally, an angle can be provided relative to the moving vector (direction of movement 115) to indicate a tilted quadratic or rectangular coverage shape.

[TS1] For a freely defined and shaped coverage area 11 as a polygon, the definition with multiple reference points (each a GNSS position) is proposed according to the present invention: Area = [RP1; RP2, RP3, i.e. reference points 1, 2, 3] equals a triangle; Area = [RP1; RP2, RP3, RP4, i.e. reference points 1, 2, 3, 4] equals a rectangle or a trapeze or a parallelogram. Hence, with such a polygon-based definition of the coverage area 11, any coverage shape is able to be described according to the present invention.

Hence, the following ASN.1 additions to SIB19 (for a rectangular coverage shape) are proposed:

-- ASN1START

-- TAG-SIB19-START

5

SIB19-r17 ::= SEQUENCE {

 ntn-Config NTN-Config-r17 OPTIONAL, -- Need R

10 t-Service-r17 INTEGER (0..549755813887) OPTIONAL, -- Need R

 referenceLocation-r17 ReferenceLocation-r17 OPTIONAL, -- Need R

 coverageShape-r18 CoverageShape-r18 OPTIONAL, -- Need R

15 ta-Report-r17 ENUMERATED {enabled} OPTIONAL, -- Need R

 lateNonCriticalExtension OCTET STRING OPTIONAL,

 ...

 }

20

ReferenceLocation-r17 ::= ENUMERATED { ffs } -- FFS

25

-- TAG-SIB19-STOP

-- ASN1STOP

30

-- ASN1START

-- TAG-COVERAGESHAPE-R18-START

35

CoverageShape-r18 ::= SEQUENCE

 highFront INTEGER (0..xxxx)

 highBack INTEGER (0..xxxx)

40 widthLeft INTEGER (0..xxxx)

 widthRight INTEGER (0..xxxx)

 Angle INTEGER (-180..180) OPTIONAL, - Need R

45 lateNonCriticalExtension OCTET STRING OPTIONAL,

 ...

 }

50

ReferenceLocation-r17 ::= ENUMERATED { ffs } -- FFS

-- TAG-COVERAGESHAPE-R18-STOP

55

-- ASN1STOP

[0051] Based on OAM (operation and maintenance) parametrisation and related signalling from the control instance to the satellite (or, to the base station entity 111 and its antenna entity or functionality 111'), the information which shape of coverage the satellite (or antenna entity or functionality 111') shall be created is needed. The OAM interface carries this information, e.g. as defined in TS38.300:

Ephemeris information describing the orbital trajectory information or coordinates for the non-terrestrial network vehicles or devices; this information is especially provided on a regular basis or upon demand to the gNB; especially two different sets of ephemeris format shall be supported:

Set 1: Satellite position and velocity state vectors: position; velocity;

Set 2: At least the following parameters in orbital parameter ephemeris format, as specified in NIMA TR 8350.2 [51]: semi-major axis; eccentricity; argument of periapsis; longitude of ascending node; inclination; mean anomaly at epoch time to.

The explicit epoch time associated to ephemeris data;

The location of the NTN-Gateways.

Claims

1. Method for enabling communication between a user equipment (20) and a mobile communication network (100), the mobile communication network (100) being or at least comprising a part corresponding to or being a non-terrestrial network, wherein the user equipment (20) is served by a base station entity (111) being part of that non-terrestrial network or that non-terrestrial network part, wherein the base station entity (111) has or is provided with - in view of serving or providing radio coverage to the user equipment (20) - at least an antenna entity or functionality (111') being either a satellite-based antenna entity or functionality, or an antenna entity or functionality based on a high-altitude platform, the antenna entity or functionality (111') moving relative to the earth surface along a direction of movement (115), thereby providing radio coverage to a radio cell (11), wherein the method comprises the step of

-- operating the antenna entity or functionality (111'), or
-- configuring the antenna entity or functionality (111') such that the shape of the coverage area of the radio cell (11) is configured or configurable in a predefined manner other than circular or elliptical.

2. Method according to claim 1, wherein the antenna entity or functionality (111') is operated or configured such that, in a first mode of operation, the shape of the coverage area of the radio cell (11) is configured or configurable in a first predefined manner other than circular or elliptical, and, in a second mode of operation, the shape of the coverage area of the radio cell (11) is configured or configurable in a second predefined manner, wherein especially the first mode of operation is applied at a first point in time or during a first time interval, and the second mode of operation is applied at a second point in time or during a second time interval.

3. Method according to one of the preceding claims, wherein the shape of the coverage area of the radio cell (11) corresponds, at least in or during one mode of operation, to one of the following:

-- a simple polygon, especially a convex polygon or a quadrilateral, especially a rectangle, a parallelogram, or a rhombus
-- regular polygon, especially an equilateral triangle, or a square, or an equilateral and equiangular pentagon, hexagon, or octagon,
-- a general polygon, especially being defined by a number of points or geographical locations such that a certain area, especially a populated area such as a city, is covered.

4. Method according to one of the preceding claims, wherein the antenna entity or functionality (111') moving relative to the earth surface along a direction of movement (115) provides radio coverage to a moving area corresponding to an earth-moving radio cell (11).

5. Method according to one of the preceding claims, wherein the antenna entity or functionality (111') moving relative to the earth surface along a direction of movement (115) provides radio coverage to a static area corresponding to an earth-fixed radio cell (11).

6. Method according to one of the preceding claims, wherein the shape of the coverage area of the radio cell (11) is configured or configurable in a predefined manner,

especially such that a rather rectangular radio cell (11) is generated, wherein especially two of the sides of the radio cell (11) or coverage area are essentially parallel to the direction of movement (115) of the antenna entity or functionality (111') or essentially parallel to the central trajectory path of the radio cell (11), wherein especially one or more of the following is realized:

- the antenna entity or functionality (111') steers, especially using multiple input multiple output beam steering or beam forming, the transmission in a manner such that the resulting coverage area approximately is or corresponds to the predefined shape of the coverage area of the radio cell (11), especially a rectangle or a rectangle having rounded corners,
- the antenna entity or functionality (111') generates at least one moving beam, or spot beam, wherein the moving beam is oriented in different spatial directions at different points in time such that the coverage area is swept through during a predetermined time interval and such that the resulting coverage area approximately is or corresponds to the predefined shape of the coverage area of the radio cell (11), especially a rectangle or a rectangle having rounded corners,
- the antenna entity or functionality (111') comprises a multitude of antenna panels, wherein the multitude of antenna panels create constructive and/or destructive interference such that the resulting coverage area approximately is or corresponds to the predefined shape of the coverage area of the radio cell (11), especially a rectangle or a rectangle having rounded corners,
- the antenna entity or functionality (111') generates a multitude of differently shaped static or quasi-static spot beams such that the resulting coverage area approximately is or corresponds to the predefined shape of the coverage area of the radio cell (11), especially a rectangle or a rectangle having rounded corners.

7. Method according to one of the preceding claims, wherein a reference location information as well as a service time information is transmitted, by the base station entity (111) or by the antenna entity or functionality (111') to the user equipment (20),

wherein the service time information relates to until when the base station entity (111), or the antenna entity or functionality (111') likely stops serving the currently covered area, wherein the reference location information corresponds, at least approximately, to the shape of the coverage area of the radio cell (11) produced or generated by the antenna entity or functionality (111'), wherein especially the base station entity (111) transmits, and the user equipment (20) receives, the reference location information and the service time information as information elements as part of a system information block, especially broadcast by the base station entity, especially system information block 19 with 3GPP NR technology (111), wherein especially the reference location information comprises, in case of a rectangularly shaped coverage area of the radio cell (11), at least one reference point information, at least one height information and/or at least one width information, preferably a first height information, a second height information, a first width information and a second width information, wherein the height information preferably corresponds to the extension of the coverage area, from the reference point, in a direction essentially parallel to the direction of movement (115) of the antenna entity or functionality (111'), and wherein the width information preferably corresponds to the extension of the coverage area, from the reference point, in a direction essentially orthogonal to the direction of movement (115) of the antenna entity or functionality (111'), wherein especially the reference location information comprises, in case of a coverage area of the radio cell (11) shaped as a simple polygon or a regular polygon or a general polygon, a plurality of pieces of reference point information, especially corresponding to the corner points of the polygonal coverage area.

8. User equipment (20) communicating with a mobile communication network (100), the mobile communication network (100) being or at least comprising a part corresponding to or being a non-terrestrial network, wherein the user equipment (20) is served by a base station entity (111) being part of that non-terrestrial network or that non-terrestrial network part, wherein the base station entity (111) has or is provided with - in view of serving or providing radio coverage to the user equipment (20) - at least an antenna entity or functionality (111') being either a satellite-based antenna entity or functionality, or an antenna entity or functionality based on a high-altitude platform, the antenna entity or functionality (111') moving relative to the earth surface along a direction of movement (115), thereby providing radio coverage to a radio cell (11), wherein the user equipment (20) is configured such that the antenna entity or functionality (111') is operated or

configured such that the shape of the coverage area of the radio cell (11) is configured or configurable in a predefined manner other than circular or elliptical.

- 5 9. Antenna entity or functionality (111') as part of a base station entity (111) for enabling communication between a user equipment (20) and a mobile communication network (100), the mobile communication network (100) being or at least comprising a part corresponding to or being a non-terrestrial network, wherein the user equipment (20) is served by the base station entity (111) being part of that non-terrestrial network or that non-terrestrial network part, wherein the base station entity (111) has or is provided with - in view of serving or providing radio coverage to the user equipment (20) - at least the antenna entity or functionality (111') being either a satellite-based antenna entity or functionality, or an antenna entity or functionality based on a high-altitude platform, the antenna entity or functionality (111') moving relative to the earth surface along a direction of movement (115), thereby providing radio coverage to a radio cell (11), wherein the antenna entity or functionality (111') is configured such that it is operated or able to be operated such that the shape of the coverage area of the radio cell (11) is configured or configurable in a predefined manner other than circular or elliptical.
10. System or mobile communication network (100) for communication between a user equipment (20) and the mobile communication network (100), the mobile communication network (100) being or at least comprising a part corresponding to or being a non-terrestrial network, wherein the user equipment (20) is served by a base station entity (111) being part of that non-terrestrial network or that non-terrestrial network part, wherein the base station entity (111) has or is provided with - in view of serving or providing radio coverage to the user equipment (20) - at least an antenna entity or functionality (111') being either a satellite-based antenna entity or functionality, or an antenna entity or functionality based on a high-altitude platform, the antenna entity or functionality (111') moving relative to the earth surface along a direction of movement (115), thereby providing radio coverage to a radio cell (11), wherein the system of mobile communication network (100) is configured such that the antenna entity or functionality (111') is operated or configured such that the shape of the coverage area of the radio cell (11) is configured or configurable in a predefined manner other than circular or elliptical.
11. Program comprising a computer readable program code, which, when executed on a computer and/or on a user equipment (20) and/or on a base station entity (111) of a mobile communication network (100) and/or on an antenna entity or functionality (111') of a base station entity (111), or in part on a user equipment (20) and/or in part on a base station entity (111) of a mobile communication network (100) and/or in part on an antenna entity or functionality (111') of a base station entity (111), causes the computer and/or the user equipment (20) and/or the base station entity (111) and/or the antenna entity or functionality (111') to perform a method according one of claims 1 to 7.
12. Computer-readable medium comprising instructions which when executed on a computer and/or on a user equipment (20) and/or on a base station entity (111) of a mobile communication network (100) and/or on an antenna entity or functionality (111') of a base station entity (111), or in part on a user equipment (20) and/or in part on a base station entity (111) of a mobile communication network (100) and/or in part on an antenna entity or functionality (111') of a base station entity (111), causes the computer and/or the user equipment (20) and/or the base station entity (111) and/or the antenna entity or functionality (111') to perform a method according one of claims 1 to 7

Amended claims in accordance with Rule 137(2) EPC.

1. Method for transmitting a service time interval and a service time information to a user equipment (20) in a mobile communication network (100), the mobile communication network (100) being or at least comprising a non-terrestrial network, wherein the user equipment (20) is served by a base station entity (111) being part of that non-terrestrial network, wherein the base station entity (111) has or is provided with at least an antenna entity or functionality (111') being either a satellite-based antenna entity or functionality, or an antenna entity or functionality based on a high-altitude platform, the antenna entity or functionality (111') moving relative to the earth surface along a direction of movement (115), thereby providing radio coverage to a moving area corresponding to an earth-moving radio cell (11), wherein the antenna entity or functionality (111') provides a coverage area such that a rather rectangular earth-moving coverage area is generated or such that a rectangular earth-moving coverage area is at least enclosed or comprised, wherein two of the sides of the rectangularly shaped earth-moving (11) or coverage area are essentially parallel to the direction of movement (115) of the earth-moving radio cell (11) or essentially parallel to the central trajectory path of the moving earth-moving radio cell (11), wherein the method comprises the following step:

-- the base station entity (111) transmits, and the user equipment (20) receives, a reference location information and the service time information, the reference location information relating to the currently covered area or a part thereof, and the service time information relating to until when the base station entity (111) likely stops serving the currently covered area.

2. Method according to claim 1, wherein one or more of the following is realized:

-- the antenna entity or functionality (111') steers, especially using multiple input multiple output beam steering or beam forming, the transmission in a manner such that the resulting coverage area approximately corresponds to a rectangularly shaped coverage area of the radio cell (11),
 -- the antenna entity or functionality (111') generates at least one moving beam, or spot beam, wherein the moving beam is oriented in different spatial directions at different points in time such that the coverage area is swept through during a predetermined time interval and such that the resulting coverage area approximately corresponds to a rectangularly shaped coverage area of the radio cell (11),
 -- the antenna entity or functionality (111') comprises a multitude of antenna panels, wherein the multitude of antenna panels create constructive and/or destructive interference such that the resulting coverage area approximately corresponds to a rectangularly shaped coverage area of the radio cell (11),
 -- the antenna entity or functionality (111') generates a multitude of differently shaped static or quasi-static spot beams such that the resulting coverage area approximately corresponds to a rectangularly shaped coverage area of the radio cell (11).

3. Method according to one of the preceding claims, wherein the reference location information defines the central part (116) of the earth-moving radio cell (11), especially the central trajectory path of the moving earth-moving radio cell (11),

wherein especially the reference location information also indicates a lateral extension of the earth-moving radio cell (11) from the central part (116) of the earth-moving radio cell (11), especially the central trajectory path of the moving earth-moving radio cell (11).

4. Method according to one of the preceding claims, wherein the reference location information defines the two lateral border parts of the earth-moving radio cell (11) in a direction essentially parallel to the direction of movement (115) of the antenna entity or functionality (111')

and/or

wherein the reference location information comprises at least one reference point information, at least one height information and/or at least one width information, preferably a first height information, a second height information, a first width information and a second width information, wherein the height information preferably corresponds to the extension of the coverage area, from the reference point, in a direction essentially parallel to the direction of movement (115) of the antenna entity or functionality (111'), and wherein the width information preferably corresponds to the extension of the coverage area, from the reference point, in a direction essentially orthogonal to the direction of movement (115) of the antenna entity or functionality (111').

5. Method according to one of the preceding claims, wherein the base station entity (111) transmits, and the user equipment (20) receives, the reference location information and the service time information as information elements as part of a system information block, especially broadcast by the base station entity, especially system information block 19 with 3GPP NR technology (111).

6. System for transmitting a service time interval and a service time information to a user equipment (20) in the mobile communication network (100), the system comprising the user equipment (20) and the mobile communication network (100), the mobile communication network (100) being or at least comprising a non-terrestrial network, wherein the user equipment (20) is served by a base station entity (111) being part of that non-terrestrial network, wherein the base station entity (111) has or is provided with at least an antenna entity or functionality (111') being either a satellite-based antenna entity or functionality, or an antenna entity or functionality based on a high-altitude platform, the antenna entity or functionality (111') being configured to move relative to the earth surface along a direction of movement (115), thereby providing radio coverage to a moving area corresponding to an earth-moving radio cell (11), wherein the antenna entity or functionality (111') is configured to provide a coverage area such that a rather rectangular earth-moving coverage area is generated or such that a rectangular earth-moving coverage area is at least enclosed or comprised, wherein two of the sides of the rectangularly shaped earth-moving coverage area are essentially parallel to the direction of movement (115) of the earth-moving radio cell (11) or essentially parallel to the central trajectory path of the moving earth-moving radio cell (11),

wherein the system is configured such that the base station entity (111) transmits, and the user equipment (20) receives, a reference location information and the service time information, the reference location information relating to the currently covered area or a part thereof, and the service time information relating to until when the base station entity (111) likely stops serving the currently covered area.

7. Base station entity (111) comprising an antenna entity or functionality (111') as part of a system according to claim 6.
8. User equipment (20) as part of a system according to claim 6.
9. Program comprising a computer readable program code, which, when executed on a computer, causes the computer to perform a method according one of claims 1 to 5.
10. Computer-readable medium comprising instructions which when executed on a computer, causes the computer to perform a method according one of claims 1 to 5.

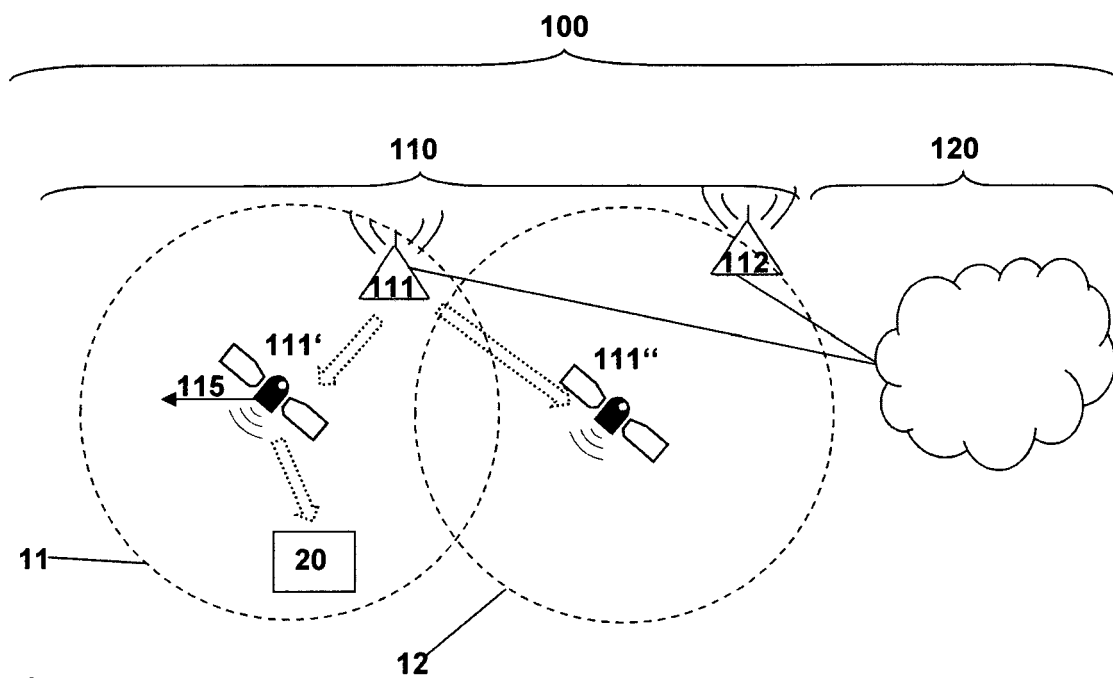


Fig. 1

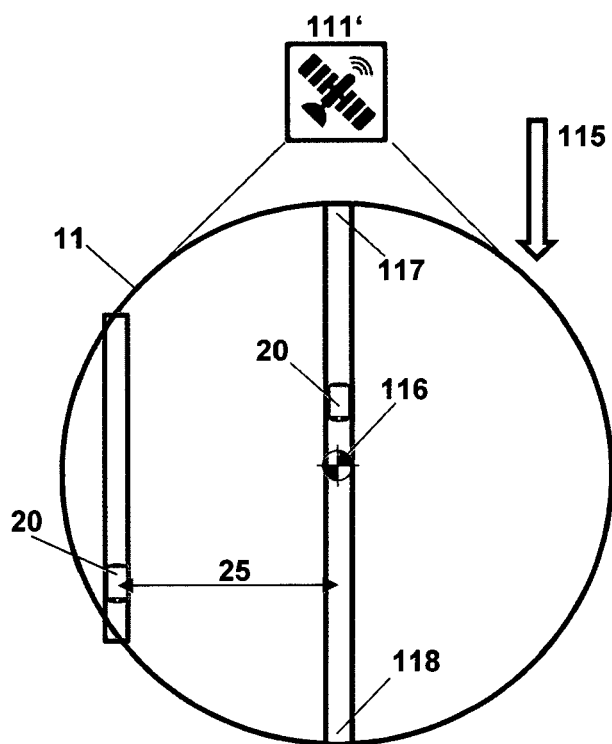


Fig. 2

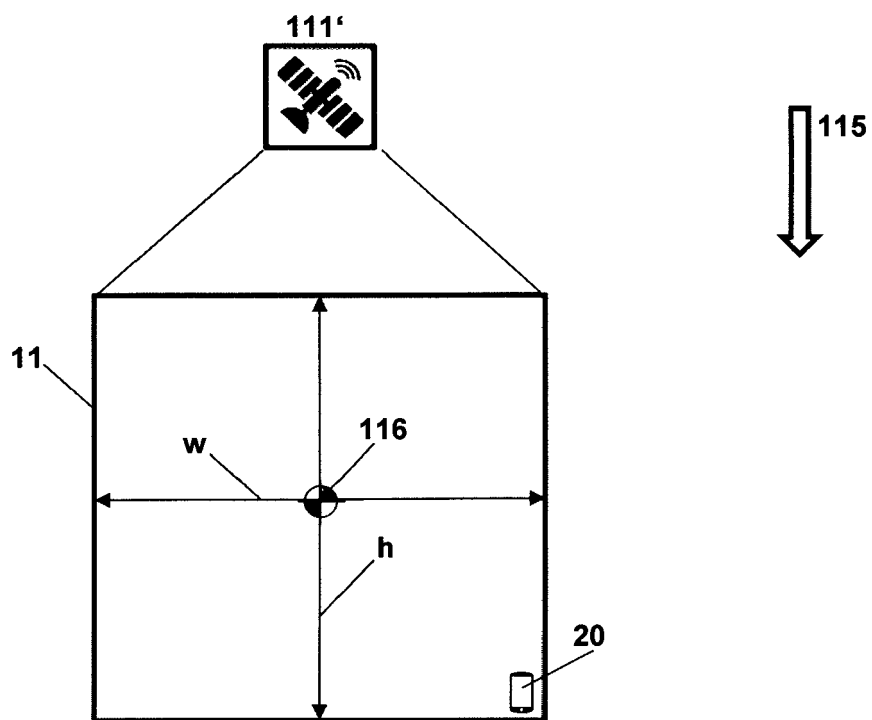


Fig. 3

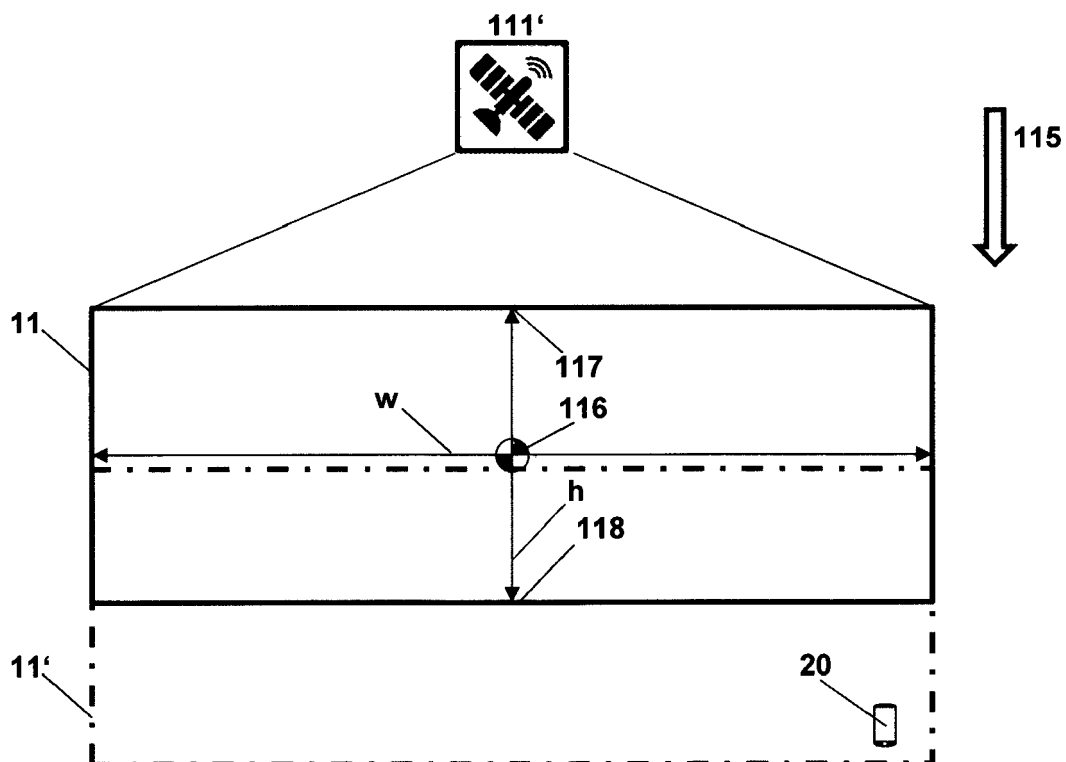


Fig. 4

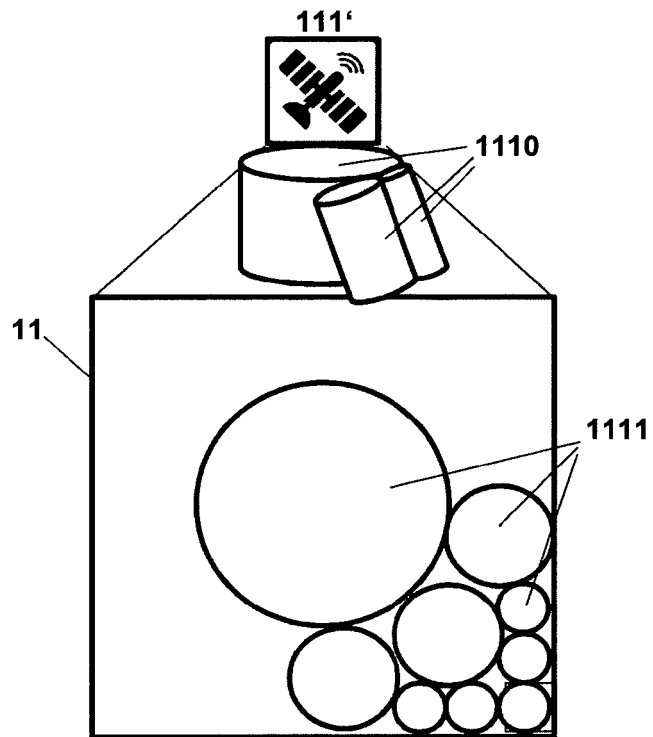


Fig. 5

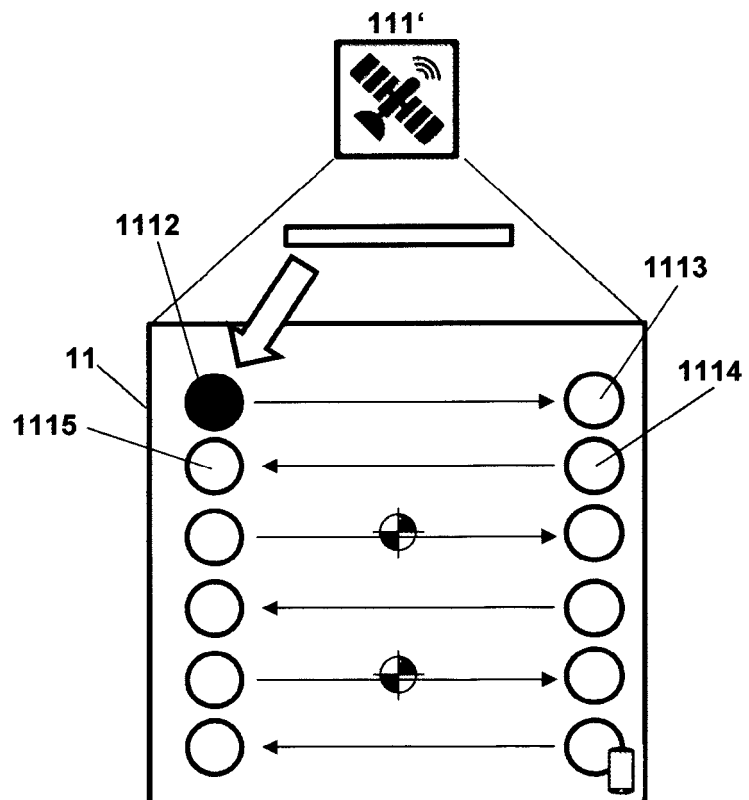


Fig. 6



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Y	* figures 13, 17, 18, 21, 25 *	7	H04B7/185
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	* paragraph [0164] *		
	* paragraph [0172] *		
	* paragraph [0189] *		
	* paragraph [0193] - paragraph [0198] *		
	* paragraph [0216] *		
	* paragraph [0241] *		
	* paragraph [0252] *		
	* paragraph [0257] - paragraph [0273] *		
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	* paragraph [0066] *		
	* paragraph [0108] - paragraph [0109] *		

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	* page 9 *		
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	* column 14, line 55 - line 67 *		
	* column 15, line 47 - column 16, line 9 *		

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	* paragraph [0206] *		
	* paragraph [0211] *		

	-/--		
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		13 March 2023	Arroyo Valles,
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X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	



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			TECHNICAL FIELDS SEARCHED (IPC)
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 13 March 2023	Examiner Arroyo Valles,
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03.82 (P04C01)



EUROPEAN SEARCH REPORT

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Y	OPPO: "Discussion on the support of discontinuous coverage for IoT over NTN", 3GPP DRAFT; R2-2107081, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. electronic; 20210809 - 20210827 6 August 2021 (2021-08-06), XP052033875, Retrieved from the Internet: URL:https://ftp.3gpp.org/tsg_ran/WG2_RL2/TSGR2_115-e/Docs/R2-2107081.zip R2-2107081 - Discussion on the support of discontinuous coverage for IoT over NTN.doc [retrieved on 2021-08-06] * Section 2.2 *	7	TECHNICAL FIELDS SEARCHED (IPC)
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		13 March 2023	Arroyo Valles,
CATEGORY OF CITED DOCUMENTS X : theory or principle underlying the invention Y : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons A : technological background O : non-written disclosure P : intermediate document & : member of the same patent family, corresponding document			

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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).



**LACK OF UNITY OF INVENTION
SHEET B**

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The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-6, 8-12

Setting the coverage area of a radio cell in non-terrestrial networks

2. claim: 7

Providing coverage information to a user equipment

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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